

IMPROVING THE ADHESION PROPERTIES OF NANOCRYSTALLINE DIAMOND FILMS BY BIAS-ENHANCED NUCLEATION

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Abstract

Nanocrystalline diamond films (including materials referred to as tetrahedrally-bonded carbon films, ultra-nanocrystalline diamond films, and nanostructured diamond films) are highly strained materials that show a strong tendency to delaminate at relatively small thickness values around 5 microns. This situation often precludes from taking advantage of the many extreme properties of diamond that make it suitable for protective and tribological coatings (i.e. extreme hardness, radiation hardness, chemical inertness). We have employed bias-enhanced nucleation (BEN) performed in a microwave-plasma chemical vapor deposition (MWCVD) system to implant seed nanostructures in the substrate that favor the formation of strongly adherent layer at the substrate-film interface. Nanocrystalline diamond films are deposited on the BEN substrates using a hot-filament chemical vapor deposition (HFCVD) system in the continuous secondary nucleation mode that results in the deposition of nanocrystalline diamond. The observed changes in the films' structure (Fig. 1) indicates the controlling role that seeding has on film evolution. Although the films remain highly strained at the nanoscale, as evidenced from the Raman spectra (Fig. 2), they can be grown to large thickness values without compromising the substrate adhesion. Thermal shock tests evidenced the ability of these films to differentially expand and contract while remaining firmly attached to the substrate. These results are discussed in terms of the formation of a thin strong disordered carbide buffer layer at the substrate-film interface capable to adjust and accommodate dynamically any lattice mismatch. The formation of this thin carbide layer is strongly enhanced by the application of BEN to the substrates.

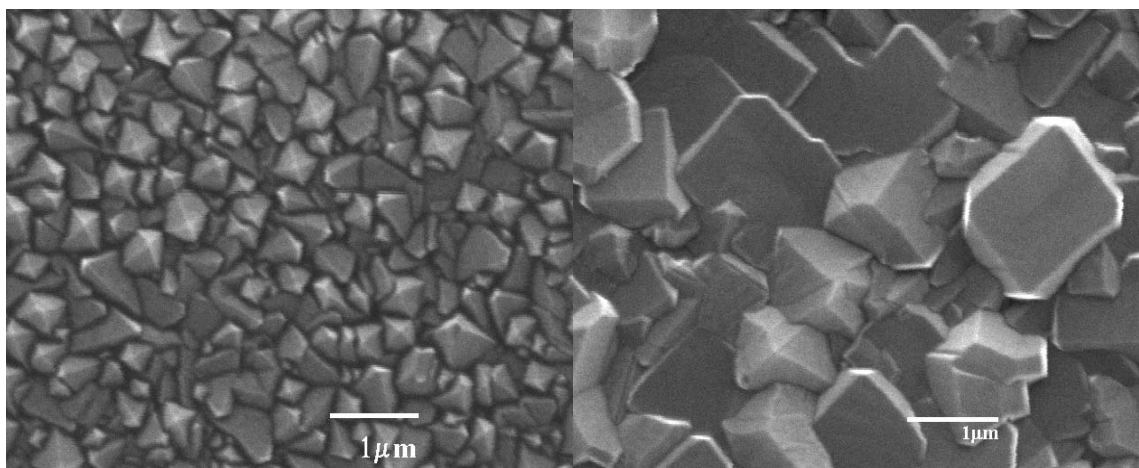


Figure 1. Substrate seeded using BEN in MWCVD (left) showing pyramidal growth habit, and diamond film grown by HFCVD on top (left) showing square growth habit.

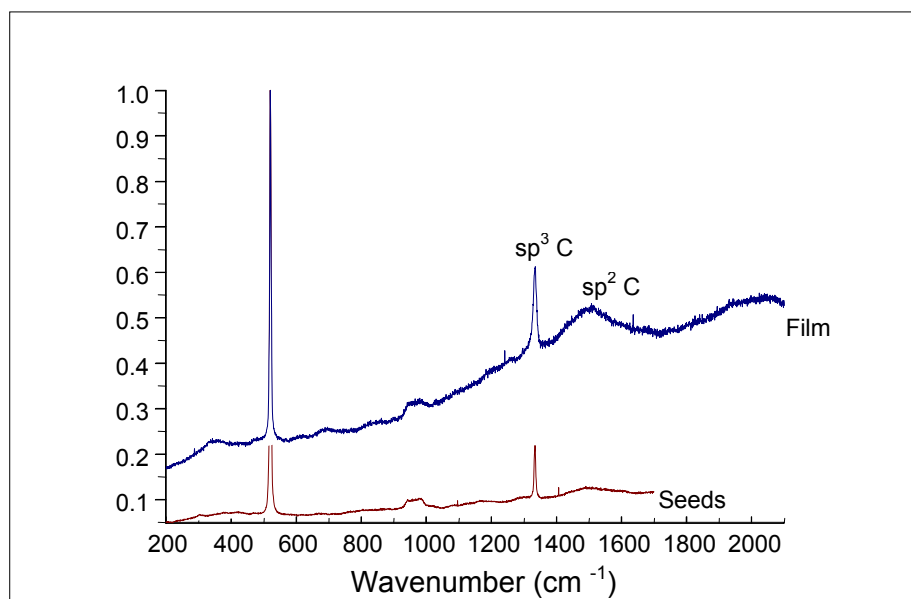


Figure 2. Microcrystalline Diamond (sp^3 C) and Graphitic Carbon (sp^2 C)
Raman features of the MWCVD BEN seeds subsequent HFCVD film

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